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# Evaluation of Monofilament Lines to Prevent Damage by Birds

Danilo A. Aguero
*University of Nebraska-Lincoln*

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# TO PREVENT DAMAGE BY BIRDS

DANILO A. AGÜERO

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by

Danilo A. Agüero

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EVALUATION OF MONOFILAMENT LINES TO PREVENT DAMAGE BY BIRDS

Danilo A. Agüero, M. S

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Advisor: Ron J. Johnson

Monofilament lines were tested at the University of Nebraska, Lincoln to determine their efficacy in preventing bird damage to grapes (Vitis spp) and house sparrow (Passer domesticus) feeding at baited sites. Seven grape cultivars were used. Experimental plants were encircled with clear 5.4 kg- (12-pound) test monofilament lines spaced 30 cm apart. Grape bunches were marked and damage recorded. Bird entries at control and experimental plants were observed and recorded during 140 15-min random intervals within 4 hours of sunrise or sunset. There were no significant differences between control and treatment plants in the number of days to reach 50% damage ($P$ = 0.43). The mean number of days for bird damage to reach 100% in all plants within a cultivar ranged from 12 $\pm$ 2.1 (Leon Millot) to 54 $\pm$ 7.5 (Bath). European starlings (Sturnus vulgaris), American robins (Turdus migratorious), and occasionally 4 other species were observed entering the treatment plants. Therefore, monofilament lines failed to prevent bird damage to grapes.

Four other experiments with controls were conducted using baited stations to evaluate house sparrow response in relation to line size [(1.8, 5.4, and 9 Kg-test (4, 12, and 20 pound-test)], orientation (north-south, east-west), color (clear and golden fluorescent-yellow), and spacing (30 and 60 cm). The experimental design was a latin square with periods and locations as blocking factors. Results of house sparrow counts and bait consumption data from control and treatments indicated that in all the experiments house sparrows were repelled by the lines ($P \leq 0.0003$). It appeared that blue jays (Cyanocitta cristata) and northern cardinals (Cardinalis cardinalis) were affected by the lines but their numbers were low and more information is required. Four other species were not repelled by the lines ($P \geq 0.16$). Overall lines appear to offer a simple, safe, and effective means to reduce problems caused by house sparrows at feeding sites. The use of

monofilament lines to exclude house sparrows from feeding sites has not been previously experimentally determined.

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# INTRODUCTION

Use of habitat and food resources by birds is often a concern when these activities conflict with interests of people (DeGrazio 1978, Booth 1983). Birds feeding on agricultural crops may cause damage, and their roosting activities may be a nuisance and a public health hazard. Control techniques used, including exclusion, food removal, repellents, toxicants, exploders, electronic devices, shooting, and traps (Booth 1983, Fitzwater 1983), are not always practical or otherwise appropriate. Any control technique by itself is often not satisfactory in suppressing damage due to birds. Consequently, a combination of techniques and the development of new methods less hazardous and more humane to animals and people are becoming important in situations where lethal techniques are not desirable or practical.

Although the use of lines to repel birds is not a new technique (McAtee and Piper 1936, Amling 1980), applications have been restricted largely to aquatic sites and species. Recently, Knight (1988) reported some procedures to protect row crops, fruit trees, vineyards, and bedded crops from bird damage using monofilament lines. These preliminary trials using monofilament lines were successful in protecting grapes and strawberries from birds, especially house sparrows (Passer domesticus) (J. M. Knight, pers. comm.). In addition, monofilament lines have also been used recently in a grid pattern to reduce damage by great-tailed grackles (Quiscalus mexicanus) in citrus crops (Tipton et al 1989). However, more work was needed to determine effectiveness, bird species and activity affected, and optimum size, color and spacing of lines.

In this project, I report the results of six experiments that tested some of these variables. The objectives of this study were to test (1) effectiveness of monofilament lines in preventing bird damage to grapes at a vineyard, (2) responses of house sparrows to horizontal monofilament lines placed over bait stations, with distinct levels of visibility (weight and color of lines), orientation (north-south, east-west), spacing (30 cm and 60 cm), and (3) whether any difference would be noted in the response of a house sparrow population experienced with lines compared to one never before exposed, and (4) to evaluate the response to monofilament lines of other species that often occur at feeding stations.

## LITERATURE REVIEW

Species. Damage to fruit crops.

The response of fruit growers to a survey (Dawson and Bull 1970) suggested that blackbirds (Turdus merula), song thrushes (T. ericetorum), mynas (Acridotheres tristis), European starlings (Sturnus vulgaris), white eyes (Zosterops lateralis), and house sparrows are the most troublesome bird species on ripening grapes, strawberries, apples, cherries, and pear crops of New Zealand . Furthermore, house sparrows (Dawson and Bull 1970, Jenzen 1974), chaffinches (Fringilla coelebs), and greenfinches (Chloris chloris) were important because they fed on fruit buds, whereas house sparrows, American goldfinches (Carduelis carduelis) and redpolls (C. flammea) fed on strawberry seeds (Dawson and Bull 1970). Results from a similar survey of grape growers in the U.S. (Crase et al. 1976) reported that starlings, sparrows (species unspecified; probably European starlings and house sparrows), and finches (Carpodacus spp) were the main species causing grape damage in California, which accounts for 90% of the total U.S. production. Other surveys on bird damage have indicated that American robins (T. migratorius) were an important species damaging grapes in Oregon, whereas California quail (Lophortyx californicus), American goldfinches and American robins were important in California (Hothem et al. 1981).

Other studies conducted in Ontario, analyzing gizzard contents, found that American robins and European starlings damaged grapes (Stevenson and Virgo 1971). The occurrence of these species were reported in 108 of 128 vineyards examined, but damage was moderate to severe in only 14 of the 108 vineyards. Similar analyses in Pennsylvania included species such as cedar waxwings (Bombicilla cedrorum), gray catbirds (Dumetella carolinensis), Swainson's thrushes (Catarus ustulatus), and song sparrows (Spizella passerina). Grape seeds were detected in the latter species (Jubb and Cunninghan 1976). This kind of analysis is useful but should not be exaggerated because individual grievances may be only locally important (Southern 1945). Other observations reported by Jarvis (1985) in South Africa found that Cape sparrows (P. melanurus), white eyes (Z. pallidus), Cape weavers (Ploecus velatus), red-wing starlings (Onychognatus morio) and European starlings were the major grape feeding species.

Boudreau (1972) examined some of the factors related to bird depredations in vineyards of California and found that starlings, cedar waxwings, American robins, house finches (C. mexicanus) and house sparrows were the most important grape-damaging species. European starlings, cedar waxwings, and American robins cause pluck damage because generally they pick the whole berry. House finches, house sparrows, and towhees (Pipilo aberti and P. fuscus) generally cause peck damage, which is a serious factor because it often results in subsequent insect damage (Boudreau 1972, Crase et al. 1976, Tobin 1984).

Sugar content is a measure of grape ripeness and apparently a relationship between bird damage and ripeness of grapes may exist, although this relationship is not yet clear (Crase et al. 1976). Sugar content and wine grape cultivar have been reported as important factors that influence bird damage (Jubb and Cunninghan 1976, Crase et al. 1976). In addition, Boudreau (1972; 1975) suggests that most bird species cannot tolerate high acid in grapes and that they must wait until the rising sugar drives the acid content down to tolerable levels (sugar-acid ratio). Apparently no bird damage has been observed on high-acid varieties. However, Stevenson and Virgo (1971) found that damage to grapes did not necessarily continue to increase with increasing ripening of the grapes, and they suggested that neither sugar nor acid content of fruit is correlated with susceptibility to bird damage. Therefore, more work is needed in determining what chemical attributes make grapes more attractive to birds.

Other factors to consider with the occurrence of bird damage are the environment in which a vineyard is located, time of day, foliage cover, season, weather, location of perches, size and color of the berry, etc. These factors affect the composition of the bird species community present in the general area of the vineyard and associated damage (Stevenson and Virgo 1971, Boudreau 1972; 1975).

Tobin (1984) measured bird consumption of grapes in a communal caged experiment, and showed that the intake varied significantly among species in terms of average grams of grapes removed from bunches. European starlings and American robins consumed about 3.5 times as much as house finches. He did not get a significant difference in consumption between starlings and robins. These trials suggested that on a per-species basis, starlings and robins should be of greater concern to vine-growers than house finches. However, house finches potentially may cause more damage than starlings and robins by pecking damage to the grapes. Therefore situations must be considered individually.

## Control Methods

Lethal techniques such as trapping and poisoning of house finch populations have been found to be fairly effective in reducing grape damage, but ineffective against starlings (Boudreau 1972, Clore 1976), even though these procedures for controlling grape damage are widely used (Dawson and Bull 1970; Crase et al 1976). Alternative non-lethal methods to reduce bird damage to fruits have included methiocarb as an aversive conditioning compound, hawk-kite devices, and netting (Conover 1982). Exploders and electronic sound devices, alarm and/or distress calls to scare birds (Dawson and Bull 1970, Stevenson and Virgo 1971, Boudreau 1972; 1975, Crase et al 1976, Clore 1976, Jarvis 1985, Johnson et al. 1985), cardboard caps to cover grape bunches, and weed management to provide alternate food for birds are other strategies that have been used to controlling bird damage (Jarvis 1985).

Methiocarb has been used as a repellent to alleviate bird damage to grapes. In California and Oregon, Hothem et al. (1981) found that this chemical at 3.1 kg/ha active ingredient reduced bird damage. However this product has been withdrawn from the market and its future status is uncertain (R. J. Johnson, pers. comm.).

Netting is a very effective exclusion method but is impractical for large acreages (Boudreau 1972, 1975). The overall cost and benefit must be considered and netting may be practical for protecting valuable and permanent crops (Dawson and Bull 1970, Stucky 1979, Feare 1984, Bollinger and Caslick 1984, and Jarvis 1985).

Exploders are a widely used control method (Dawson and Bull 1970, Stevenson and Virgo 1971, Crase et al 1976, Clore 1976, Jarvis 1985). However Stevenson and Virgo (1971) reported that species such as American robins did not respond to these sounds. These methods may be effective only temporarily because birds habituate to them (Boudreau 1972; 1975). Other dispersal sounds have shown some effectiveness on European starlings, especially when the sounds have biological importance (Johnson et al. 1985). However, after many repetitions birds also showed habituation to biologically notable sounds.

Cardboard caps to protect grape bunches and weed management are approaches to provide alternate food for birds and reduce damage to grapes (Jarvis 1985). Weeds provided food for sparrows when grapes were available (ripe stage). This strategy, using tillage plots, alfalfa fields, and permanent pastures to attract starlings has been discussed by Boudreau (1972; 1975).

Another non lethal technique for repelling or excluding birds is stretching wires, nylon strings, or monofilament lines across sites needing protection. This technique has been effective with bird species such as gulls, some waterfowl, and recently some terrestrial birds. Wire lines spaced at 6, 9, 15, and 24 m intervals have been useful in repelling ring-billed gulls (Larus delawarensis), herring gulls (Larus argentatus) and gulls (species unspecified) from water reservoirs to avoid pollution from droppings and uneaten items (McAtee and Piper 1936, Amling 1984). Also, overhead wires at 6 m spacing were effective in excluding ring-billed gulls and herring gulls (McLaren et al. 1984) ring billed gulls, fish crows (Corvus ossifragus) and common crows (C. brachyrhinchus) (Forsythe and Austin 1984) from sanitary landfills next to airports. Parallel and zig-zag overhead wires spaced 11 m apart kept off pigeons (species unspecified) from broccoli crops (Wright 1958), 2 m spacing repelled ring-billed gulls from recreational public places to prevent harassment of people by these birds (Blokpoel and Tessier 1984), and 6 m parallel wires over ponds prevented use by Canada geese (Branta canadensis) (Terry, unpubl. report, 1984). Terry (1984) reported that a 6 x 6 m wire grid system significantly reduced canvasback (Aythya valisineria), lesser scaup (A. afinis), American widgeon (Anas americana), and Canada goose numbers at a site, and a 3 x 3 m grid caused a slight reduction in mallards (A. platyrhynchos), black ducks (A. rubripes), green-winged teal (A. crecca), blue-winged teal (A. discors), ring-necked ducks (Aythya collaris), hooded mergansers (Lophodytes cucullatus), and ruddy ducks (Oxyura jamaicensis). Nylon strings have been used on sown cereals, seed grass, and beet crops to prevent damage by Brant geese (Branta bernicla bernicla) (Pfeiffer 1977).

Similarly, monofilament fishing lines have been used at nesting sites of ring-billed gulls (Blokpoel and Tessier 1983) at hatcheries to avoid fish predation by herring gull (Ostergaard 1981) and at public-open air places (Blokpoel and Tessier 1984). Recently, preliminary trials in which monofilament lines spaced 30 cm apart, showed success in protecting grapes and strawberries from terrestrial birds, especially house sparrows (J. M. Knight, pers. comm.). Knight (1988) also reported some procedures for protecting row crops, fruit trees, vineyards, and bedded crops from bird damage. Monofilament lines used in a grid pattern in citrus crops reduced damage by great-tailed grackles (Quiscalus mexicanus) (Tipton et al. 1989).

Although the reasons why lines repel certain birds is not fully understood, it is thought that they repel because the birds affected can see them, but not well enough to avoid them easily (Dolbeer et al. 1986, Knight 1988). It may be that flying birds looking for food focus their attention on the ground and unexpectedly fly into a line when gliding down (Blokpoel and Tessier 1984). McAtee and Piper (1936) suggested that the correct distance between wires would depend of the species to be repelled, making size and wingspread of the bird important. However there are no apparent patterns among species that explain the efficacy of lines in repelling various birds (Pochop et al. 1990).

House sparrow

The house sparrow is a member of the Family Passeridae or old world sparrows (Long 1981, American Ornithologists' Union 1983). Prior to 1982, it was a subfamily of Passerinae in the Family Ploceidae (The weavers) (Bent 1958, Imhof 1962, Summers-Smith 1963, Reilly 1968).

This species is not popular among most people. Its' unpopularity stems from the fact that is an introduced species in the U.S., has commensal habits, and displaces indigenous species. The success of the house sparrow as a colonist and an introduced species is well known. It probably now occupies two-thirds or more of the earth's surface and is still spreading in many areas (Long 1981). Today it populates between 6 and 70 degrees latitude in the northern hemisphere and from 12 to 55 degrees in the southern hemisphere and from sea level to 4,500 m (15,000 feet) above sea level (Kendeigh 1973). The first recorded introduction of the species in the U.S. was in 1850 (Barrows 1889, Wetmore 1964), and in Nebraska at Nebraska City in the 1870's (Barrows 1889, Ducey 1988). The reasons for introducing the house sparrow were aesthetics and/or to help control insect pests (Barrows 1889, Wetmore 1964, Ryser 1985).

According to Johnston and Klitz (1977), due to monoculture, long-term grain storage, livestock and farm practices, each region of the world has a set of birds that exploit food opportunities around these areas. Therefore, in some places the most abundant birds are commensals. Only a few species are persistently committed to commensalism, and only one, the house sparrow, seems to be an obligate commensal (Johnston and Klitz 1977). This species is associated with human activity, breeding in cities, suburbs, and around farm buildings (Imhof 1962, Summers-Smith 1963, Reilly 1968, Johnsgard 1979, Ryser 1985). Individual birds can live off discarded human and animal foods such as garbage, bread crumbs, refuse, fast food from restaurants, and manure (Weaver 1942, Southern 1945, Imhof 1962). Because of their commensal attributes, house sparrows often conflict with the interests of people (Johnston and Klitz 1977). They may carry pathogens. The house sparrow has been implicated in the spread of some diseases affecting people. An epidemic of encephalitis occurred in Mcleansboro, southern Illinois in 1964, in which 22 cases were diagnosed including two deaths from encephalitis. Tissues from 3 house sparrows, a chimney swift (Chaetura pelagica), and a catbird (Dumetella carolinensis) yielded strains of SLE virus (Kokernot et al. 1967). Surveillance of arbovirus activity has continued since that outbreak (Kokernot et al. 1967). In Brazil, Smith (1973) reported that house sparrows may help to spread Chagas' disease, (a tropical infection sometimes fatal to people) by carrying the first instar nymphs of the insect vector (Triatoma sordida) in their feathers. These nymphs can be picked up from areas near nests and then carried from house to house. In France, Grulet et al. (1982) reported a natural intestinal infection of Isospora (a Genus of Protozoa Coccidia that commonly parasitizes people. Infections are acquired through ingestion of oocysts from human or animal feces). In the house sparrow they found at least 9 species of these Protozoa, some of them present year round. However, intensity of infections varied with Protozoan species and season.

Another factor frequently raised is that house sparrows displace indigenous species. In the U.S., the house sparrow has been accused of usurping nesting burrows of Bank swallows (Riparia riparia) (Ryser 1985), northern cliff swallows (Petrochelidon albifrons) (Stoner 1939, Buss 1942, Bent 1958, Summers-Smith 1963) and cliff swallows (P. pyrrhonota) (Samuel 1969). Bent (1958) reported that house sparrows occupied only deserted nests of cliff or barn swallows (Hirundo rustica). However, Buss (1942) reported that on a farm in Wisconsin a population of cliff swallows was increased 100% in at least 38 years by controlling the population of house sparrows by shooting. Also the purple finch (C. purpureus) declined as the house sparrow spread across the U.S. (Wetmore 1964). In Argentina, Burger (1976) reported observations of competitive exclusion of the Hornero or rufous ovenbird (Furnarius rufus) from nest sites by house sparrows. Additionally, competition with the house martin (Dolichon urbica) (Southern 1945, Summers-Smith 1963), house finch, (Bent 1958) and rock doves (Columba livia) (Bunni 1979) for nesting sites has been documented.

Populations of bluebirds (Sialia spp) have also been noted to decline in the presence of house sparrows (Rue 1970). Although not fully understood, Zeleny (1976) suggested that scarce food supply in winter, insecticide use, habitat destruction, and competition with alien birds such as house sparrows (Bent 1958) and starlings were important factors.

In spite of the bad reputation of the house sparrow, Southern (1945) suggested that the species may be useful in certain habitats (fruit growing areas and towns), and in certain specific circumstances. Studies of stomachs from 8,004 adults and 337 nestling house sparrows grouped the items in relation to beneficial or harmful to the interests of the people (Kalmbach 1940). He found that feeding habits of the adults were 56% harmful while those of the nestlings were 59% beneficial. But unfortunately, the feeding time of the latter is very limited (Bent 1958). Another beneficial aspect is that house sparrows tend to be more easily disturbed at feeding patches than others birds (Arbid and Soper 1972, Dennis 1978). This seems to be because the species is more attentive to predators such as cats, raptors, and others. This advantage may be exploited by related species such as dickcissels (Spiza americana) that oftèn have been seen flocking with house sparrows at backyard feeders (Dennis 1978).

# CHAPTER 1

# MONOFILAMENT LINES FAIL TO PROTECT GRAPES FROM BIRD DAMAGE

# MONOFILAMENT LINES FAIL TO PROTECT GRAPES FROM BIRD DAMAGE

## ABSTRACT

Monofilament lines, were tested to determine their efficacy in preventing bird damage to grapes (Vitis spp). Seven grape cultivars, each with 4-8 plants, were used. Experimental plants were encircled with clear 5.4 Kg- (12-pound) test monofilament lines spaced 30 cm apart and tied to circles of rigid 9 gauge wire on either end of the plant. All grape bunches were marked and damage recorded. Bird entries at control and experimental plant were observed and recorded during 140 15-min random intervals within 4 hours of sunrise or sunset. An independent two-sample t-test showed no significant differences between control and treatment plants in days to reach 50% damage ($P$ = 0.43). The mean number of days for bird damage to reach 100% in all plants within a cultivar ranged from 12 $\pm$ 2.1 (Leon Millot) to 54 $\pm$ 7.5 (Bath). European starlings (Sturnus vulgaris), American robins (Turdus migratorious) (the two primary species present), northern orioles (Icterus galbula), northern cardinals (Cardinalis cardinalis), brown thrashers (Toxostoma rufum), and American goldfinches (Carduelis tristis) were observed passing through the lines around treatment plants. Consequently monofilament lines failed to protect grapes because all plants reached 100% damage through the ripening process.

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Key words: Bird damage, control, monofilament lines, grapes (Vitis spp), (Sturnus vulgaris), (Turdus migratorius), (Icterus galbula), (Cardinalis cardinalis), (Toxostoma rufum), (Carduelis tristis), vineyards.

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Birds feeding on agricultural crops may cause economic losses. Current control techniques used are not always practical or otherwise appropriate. Consequently, a combination of techniques and the development of new methods are always welcome to improve control effectiveness. Monofilament lines, a new control technique in terrestrial birds, was reported by Knight (1988) to protect row crops, fruit trees, vineyards, and bedded crops from bird damage. These preliminary trials using monofilament lines were successful in protecting grapes and strawberries from birds, especially house sparrows (Passer domesticus) (J. M. Knight, pers. comm.). In addition, monofilament lines have also been used in a grid pattern to reduce damage by great-tailed grackles (Quiscalus mexicanus) in Citrus crops (Tipton et al 1989). However, more work is needed to determine effectiveness; species affected; and optimum size, color, and spacing of lines.

The objective of this study was to determine the effectiveness of monofilament lines in protecting ripening grapes from bird damage and to observe how damage-causing species behave in relation to the lines. If lines are effective, plants protected with lines should have no damage or at least less damage than control plants.

## STUDY SITE AND METHODS

The vineyard of The University of Nebraska, East Campus, Horticultural garden was selected because of its availability and its history of bird damage ranging from 30% to 100% of the crop (D. A. Steinegger, pers. comm.). The study was conducted from 15 July through 25 September 1988. Seven grape cultivars, each with four or more plants were selected. Five plants of cultivar 7 (Reliance), 5 plants of cultivar 12 (New York Muscat), 6 plants of cultivar 18 (McCampbell), 8 plants of cultivar 22 (Bath), 6 plants of cultivar 27 (Vine Red), 4 plants of cultivar 30 (Fredonia), and 8 plants of cultivar 42 (Leon Millot) were chosen (table 1.1). Each grape bunch on experimental and control plants was marked and visually examined before ripe. Clear 5.4 Kg-test (12 pound-test) monofilament lines (Stren, E. I. Dupont De Nemours & Co. Wilmington, DE) spaced 30 cm apart were attached horizontally and parallel 30 cm apart between two rigid 0.40 mm dia. (0.16 in. dia.; ~9 gauge U.S. standard) wire hoops (100 cm diameter). Wire hoops were supported by a 2 x 2 inch piece of wood attached to the poles of the grape fence. This device (fig 1.1) was placed on each experimental plant. This installation procedure is a modification of the wire half-circle suggested by Knight (1988). The amount of damage was estimated by examining each grape bunch every 4-5 days during the ripening process and the percentage of bird damage to a plant was assessed by averaging the individual bunch ratings, according to the scale of Hothem et al. (1981). The scale assessed 10 levels of damage as follows: 0 = 0%, 1 = 2.5%, 2 = 10%, 3 = 21%, 4 = 35%, 5 = 50%, 6 = 65%, 7 = 79%, 8 = 90%, 9 = 97.5%, and 10 = 100%. The same observer assessed damage to all selected cultivars in 1 day. Day 1 for these counts was assumed when bird damage was first noticed on the cultivar at the beginning of the ripening process. The device was set on July, 17 1988, and damage counts for all cultivars began on July 23. Results were analyzed using an independent two sample t-test to compare days to 50% damage between treatment and control plants.

Bird use of grape plants was quantified during 140 15-min observation intervals, randomly selected from 11 mornings and 24 evenings 4 hours after sunrise and 4 hours before sunset, the time period when most activity occurs (Hothem et al. 1981). During each 15-minute interval, 1 control and 1 experimental plant were randomly selected from a cultivar and all birds that went to these plants were recorded. These observations were made from 9 August through 24 September 1988.

## RESULTS AND DISCUSSION

Bird damage was 100% in all grape cultivars regardless of treatment. The mean number of days for damage to reach 100% in all plants within a cultivar ranged from 12 $\pm$ 2.1 (Leon Millot) to 54 $\pm$ 7.5 (Bath) (fig 1-2). A comparison between control and treatment plants for all cultivars showed no difference in the number of days to reach 50% damage ($t = -0.80$, $df = 6$; $P = 0.43$). European starlings (Sturnus vulgaris), American robins (Turdus migratorious), northern orioles (Icterus galbula), northern cardinals (Cardinalis cardinalis), brown thrashers (Toxostoma rufum), and American goldfinches (Carduelis tristis) were observed going through the lines into treatment plants. European starlings were observed passing through the lines 32 times, 24 by flying and 8 by hopping through the frame perch of the device. Northern orioles were observed flying through the lines 14 times and hopping from the frame 15. Northern cardinals were observed passing through the lines 4 times, 1 by flying through and 3 by hopping from the frame perch. American robins were observed passing through the lines 3 times, 2 by flying and 1 by hopping from the ground. During the period between 20 July (start of damage counts) and 9 August (start of bird observations) 1988, robins were observed damaging grapes, but these observations were not included in bird counts. Shortly after bird observations began, robins disappeared from the site. An empty robin's nest was found in one of the plants of the cultivar Fredonia. Brown thrashers and American goldfinches were observed going through the lines one time each, by hopping from the ground or by flying, respectively. Results show that most of the bird species entering treatment plants were flying or, to a lesser extent, hopping from a perch on either the 2 x 2 piece of wood or on the 9 gauge wire frame of the device. The total number of birds observed were 70 on treatment and 11 (all European starlings) on control plants. These bird observation results may not be a true comparison sample of treatment versus control because they may be due to bias of the observer from a tendency to pay more attention to the treatment plants than the control.

Moreover, all grapes reached 100% damage and damage within cultivars occurred at similar rates in treatments and controls. These damage results indicate also no true difference in bird use of the treatment and control plants. However observation of fewer birds on control than on treatment may indicate that the device possibly attracted birds perhaps by serving as a marker of ripening grapes. Further, more controlled observations will be necessary to capably resolve this point. However, data do support the substantial issue that 6 species of birds did pass through the lines by flying as well as by hopping. The results may reinforce the point that the lines are ineffective in controlling damage due to these species of birds.

In this study, monofilament lines failed to prevent bird damage to grapes. Cultivars Bath and McCampbell had the highest number of days to reach 100% bird damage in all plants in comparison with the rest of the cultivars (fig 1.2). Apparently the cultivar Leon Millot was most vulnerable to bird damage. This response may be related to the size of the grape and the presence at the vineyard of European starlings and American robins responsible for pluck damage. But an important outcome here in relation to monofilament lines was that bird damage to grapes reached 100% in both experimental and control plants. Therefore lines were ineffective in stopping or reducing bird damage. Monofilament lines did not deter or exclude American robins and European starlings from eating grapes or flying to the treatment plants.

The reasons why lines repel certain birds is not fully understood and there are no apparent overall patterns among species that explain the efficacy of lines in repelling various birds (Pochop et al. 1990). It is thought that lines repel because the birds affected can see them, but not well enough to avoid them easily (Dolbeer et al. 1986, Knight 1988). It may be that flying birds looking for food focus their attention on the ground and unexpectedly fly into a line when gliding down (Blokpoel and Tessier 1984). Since grape rows in this experiment had a north-south orientation, one possible explanation for these results was that sunlight reflecting off the lines in the early morning and evening may have made them more visible. Therefore, these bird species

Table 1.1. Grape cultivar and number of control (without lines) and experimental (with lines) plants of each, University of Nebraska, East Campus, Lincoln, Nebraska, Jul-Oct 1988.

| Grape cultivar | Control plants | Experimental plants | total |
|---|---|---|---|
| Reliance | 2 | 3 | 5 |
| New York Muscat | 2 | 3 | 5 |
| McCampbell | 3 | 3 | 6 |
| Bath | 4 | 4 | 8 |
| Vine Red | 3 | 3 | 6 |
| Fredonia | 2 | 2 | 4 |
| Leon Millot | 4 | 4 | 8 |

were not repelled by the monofilament lines. Line size and orientation could be important in bird response. Another variable is bird species. American robins and European starlings may be species that are relatively unaffected by lines.

McAtee and Piper (1936) suggested that the correct distance between lines would depend on the species to be repelled, making size and wingspread of the bird important. For European starlings and American robins, 30 cm between monofilament lines would appear to be a barrier in relation to the wingspan of the species that, according to Rue (1970), is 37.5 cm (15 in.) for both European starlings and American robins. Indeed other traits in relation to these species must be considered. Birds flying through a plant with horizontal lines would have their wings aligned properly. However, if rapid escape in any direction became necessary, then correct maneuverability would be difficult (e.g flying upwards) in the response.

Monofilament lines failed to protect grapes from bird damage in this study. European starlings, American robins, and 4 other species of birds were not effectively repelled by the lines under these conditions.

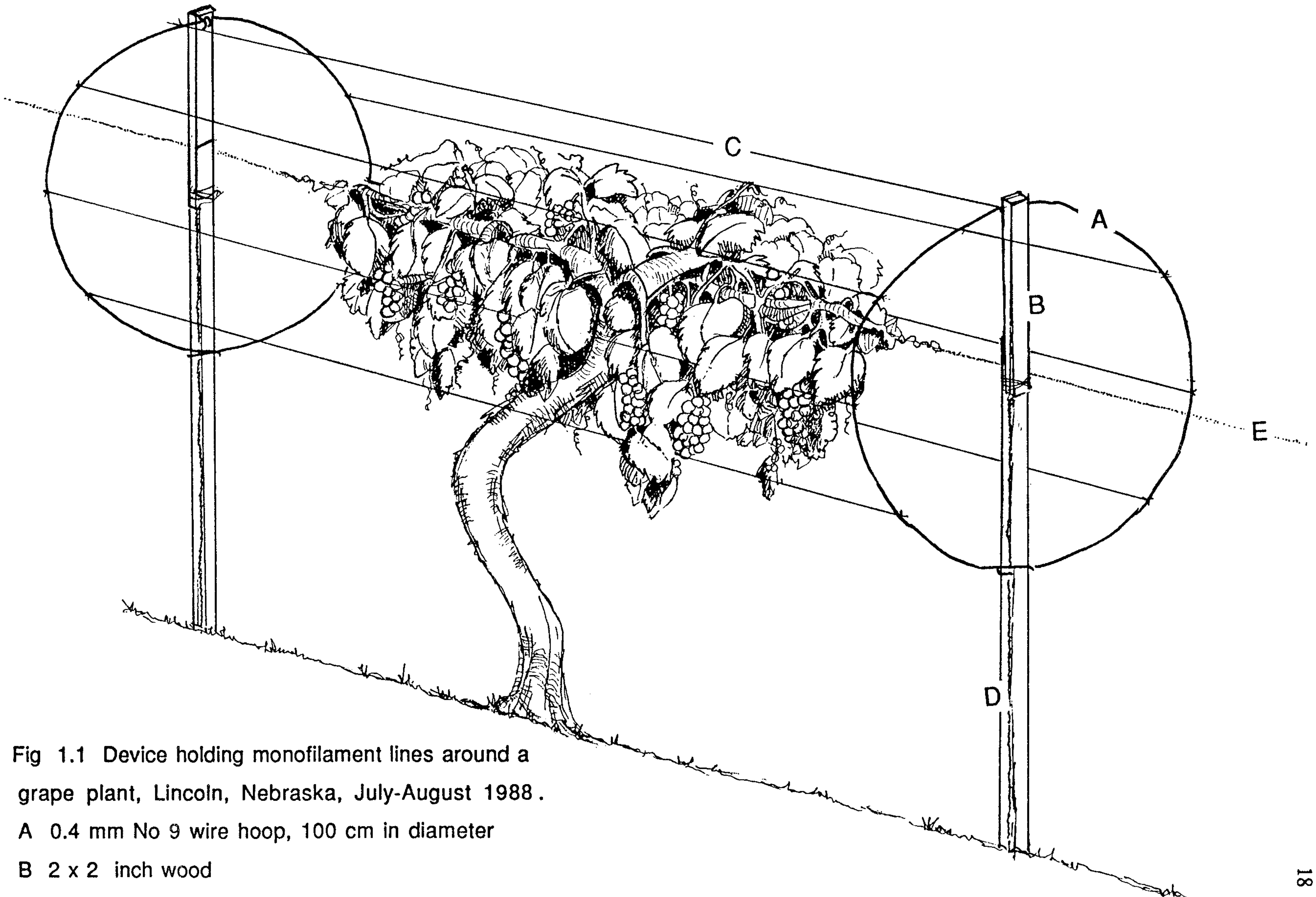


Fig 1.1 Device holding monofilament lines around a grape plant, Lincoln, Nebraska, July-August 1988.

A 0.4 mm No 9 wire hoop, 100 cm in diameter

B 2 x 2 inch wood

C Monofilament line

D Pole of the grape fence

E Plant support

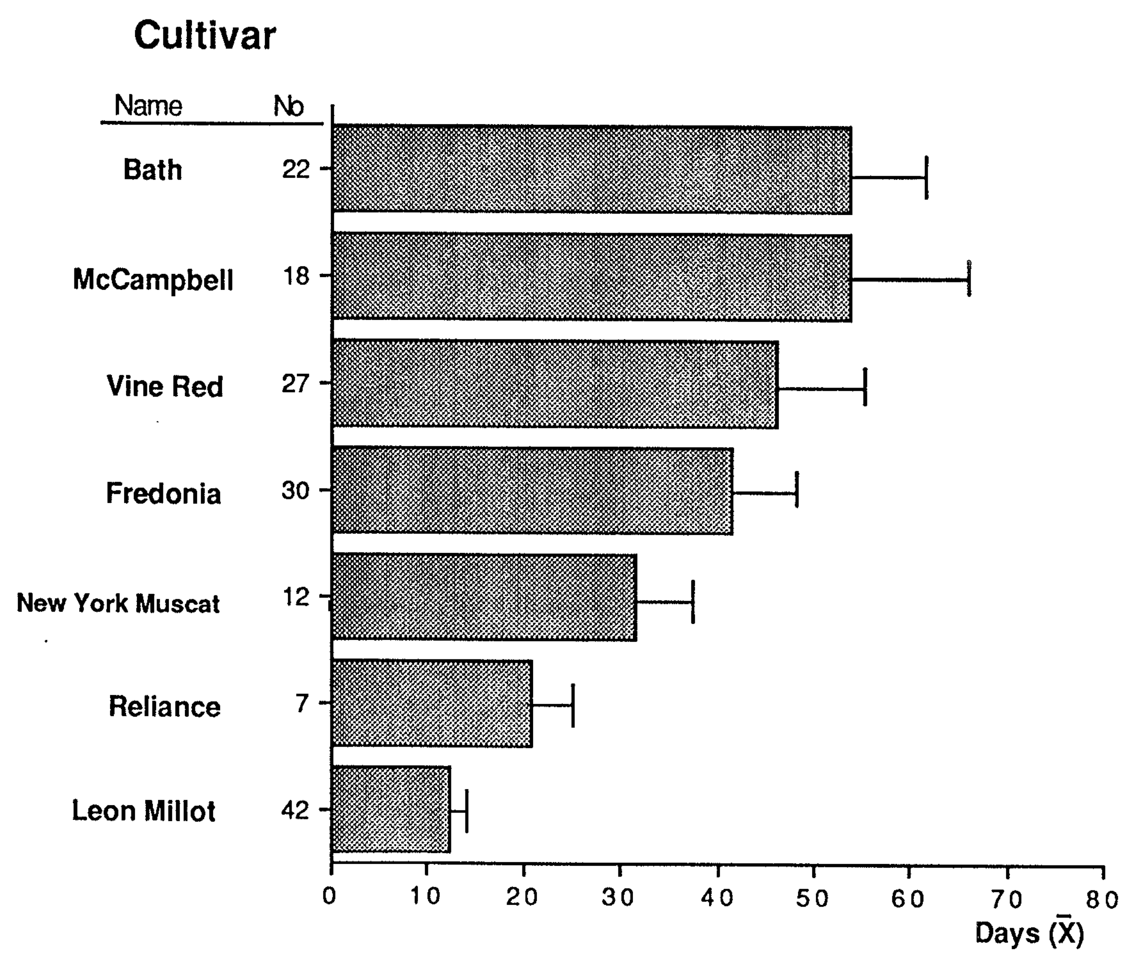


Fig 1.2. Mean number of days for bird damage to reach 100% in all plants within various grape cultivars, Lincoln, Nebraska, Jul-Aug 1988.

# CHAPTER 2

# MONOFILAMENT LINES REPEL HOUSE SPARROWS FROM FEEDING SITES

# MONOFILAMENT LINES REPEL HOUSE SPARROWS FROM FEEDING SITES

Because of their commensal attributes, house sparrows (Passer domesticus) often cause conflicts with the interests of people (Johnston and Klitz 1977). They may carry pathogens (Kokernot et al. 1967, Smith 1973, Grulet et al. 1982), damage fruit crops (Dawson 1970; Dawson and Bull 1970; Boudreau 1972, 1975; Jarvis 1985), consume and pollute livestock feed and water, and consume stored and unharvested grains (Dawson 1970). Current methods of control may include exclusion, repellents, toxicants, traps, and shooting (Booth 1983, Fitzwater 1983). However, these methods are not always practical or appropriate.

Monofilament lines have been used effectively to repel gulls, some waterfowl species, and crows (McAtee and Piper 1936; Ostergaard 1981, Blokpoel and Tessier 1984; Forsythe and Austin 1984;). Recently, observations have shown that lines spaced 30 cm apart might be successful in protecting grapes and strawberries from birds, especially house sparrows, and in repelling barn swallows (Hirundo rustica) from nesting sites (Knight 1988). Additionally lines placed in a grid pattern reduced damage by Great-tailed grackles (Quiscalus mexicanus) in citrus (Tipton et al 1989). However, using monofilament lines for terrestrial bird species is a relatively new relatively and more work is needed to test variables such as size and space.

An initial experiment was conducted at the University of Nebraska vineyard using monofilament lines to protect grapes from bird damage, particularly European starlings (Sturnus vulgaris) and American robins (Turdus migratorious). Installation procedures were similar to those used by Knight (1988) but results were different from the outcome expected. Comparisons of control and treatment plants showed that monofilament lines did not prevent bird access to plants nor damage to grapes (Chapter 1). Because grape rows had a north-south orientation at the vineyard, one possible explanation for these results was the high visibility of the lines caused by morning and evening sunlight reflections. Another possible explanation was that the birds damaging grapes at our vineyard were species not repelled by lines.

Therefore, the first experiment designed and reported here tested orientation and size of the lines, which might affect visibility, and focused on house sparrows, a species that Knight reported specifically to be repelled by the lines. The purpose of this experiment was to test the effectiveness of monofilament lines in preventing house sparrow use of feeding sites and to determine if response varied with weight and orientation of line. The hypothesis was that orientation would alter response because of effects on visibility and that larger line sizes would be more visible and less effective than smaller.

A second experiment examined responses of house sparrows to horizontal monofilament lines placed over bait stations, with distinct levels of visibility and spacing. It evaluated 2 line spacings (30, 60 cm) and tested the suggestion by Dolbeer et al. (1986) and Knight (1988) that birds avoid lines because they can see them but not well enough to avoid them easily. The hypotheses were that a wider spacing (60 cm) would be less effective than a narrow spacing (30 cm), and that if the Dolbeer et al. (1986) and Knight (1988) suggestion was correct, then highly visible lines (fluorescent yellow, 20 pound-test) would be less effective than moderately visible ones (clear, 12 pound-test).

A third experiment examined whether any difference would be noted in the response of a house sparrow population experienced with lines compared to one never before exposed.
In preliminary trials to better understand house sparrow response to various line spacings (Appendix 1), conducted at the same site as experiments 1 and 2, monofilament lines were still highly effective but more house sparrows were recorded under the lines than in earlier tests. More house sparrows under lines might indicate that these sparrows were beginning to habituate to the lines or that a late-spring/summer seasonal effect was altering their response. Therefore, the third experiment (3a and 3b) was designed to compare the response of the population of house sparrows

exposed to monofilament lines in these earlier experiments to that of population not exposed. The purpose was to determine whether the previously exposed house sparrows were beginning to show habituation to the technique or whether the change in response observed was because of a seasonal effect. If habituation was occurring, then the population previously exposed would be expected to have higher numbers feeding under the lines than population not exposed. No difference in response to lines between the two populations would indicate a seasonal effect.

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Key words: monofilament lines, house sparrow, bird damage contrôl, feeding, feeders, bait station, Passer domesticus, habituation

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## STUDY SITES AND METHODS

Experiment 1

The study was conducted from 28 December 1988 through 14 January 1989 and was located in an open area immediately north of an old barn on the University of Nebraska East Campus. Five bait stations were constructed using 60 x 60 cm piece of 1.3 cm thick plywood with a 4 cm high outside edge to avoid grain loss. Four aluminum dowels, 45 cm in length and 0.5 cm in dia, were covered with camouflage canvas tape and were used to form a square 120 x 120 cm around the bait station (fig 2.1). A frame constructed of single monofilament line was used to connect the poles and to support one or two supplemental lines according to the chosen spacing and orientation for the test. The bait stations were prebaited with finely cracked corn for a minimum of 10 days to establish a feeding pattern and to determine the amount of bait to use so that it would be mostly consumed by 4 h after sunrise. On each station, 50 g of this bait was placed at dawn and collected 4 h after sunrise. The experiment was run for 18 days. During days 1-3, all bait stations were unprotected (without lines) to collect data on bait consumption and bird species use. On day 4, one control station without lines and four treatment stations were set up. Two of the treatments used clear 5.4 kg-test (12 pound-test) monofilament lines (Stren, E. I. Dupont De Nemours & Co. Wilmington, DE) with either a north-south or an east-west orientation. The other two treatments used clear 1.8 kg-test (4 pound-test) lines with a north-south or an east-west orientation. All treatment lines were spaced 30 cm apart over each bait station at a height of 17 cm above the food. Stations were located approximately 5 m apart and in a line 15-18 m to the north of the barn. Birds were observed with binoculars (7 x 50) from a second floor window of this building. Observations were made during 4 15-minute intervals randomly selected during the first 4 h after sunrise, after which any remaining bait was removed and consumption was recorded. During observation periods, instantaneous counts of the birds at each bait station were recorded each minute, starting with 0 (16 observations per interval). The experimental design was a 5 x 5 latin square with period and location as blocking factors and where the experimental unit was station. Therefore, control and treatments were randomly rotated among the bait stations every 3 days until each station had received each treatment. Results of bird counts (bird-min) and bait consumption were analyzed using analysis of variance and specific comparisons were made using orthogonal contrasts. Contrasts used were: treatments versus control, north-south versus east west orientations, and 1.8 kg-test (4 pound-test) versus 5.4 kg-test (12 pound-test) lines.

## Experiment 2

This study was conducted from 31 January through 23 February 1989, and experimental design, site, bait stations, amount and type of bait, length of the experiment, observation site, prebait period, data collected, and data analysis were the same as in experiment 1. However the 4 daily observation intervals were randomly selected within 3 h after sunrise instead of 4 h, because the bait on the control station in experiment 1 was consumed by 3 h after sunrise.

One control and four treatments were used. Two treatments had clear 5.4 kg-test (12 pound-test) monofilament lines at either 30 or 60 cm spacing, and the other two treatments had golden (fluorescent yellow) 9 kg-test (20 pound-test) lines at 30 or 60 cm spacing. Comparisons made using orthogonal contrasts were: treatments versus control, 30 versus 60 cm spacing, and clear 12 pound-test versus golden 20 pound-test.

Experiments 3a and 3b

This study was conducted from 28 May through 14 June 1989 and there were two locations. The first location was the old barn site used in experiments 1 and 2 and the other was the University of Nebraska Agronomy farm at 84$^{th}$ street and Havelock Avenue, Lincoln. Experimental design, amount and type of bait, data collected, and data analysis were the same as in experiments 1 and 2. At the Agronomy farm, birds were observed with binoculars (7 x 50) from a van positioned approximately 20 m from and parallel to the row of stations. Ten bait stations (5 per location) were used. Treatments and control were the same as experiment 2. Where possible, age and sex of birds on treatment stations were recorded because limited evidence from the literature indicated that juveniles birds may pass through lines more readily than adults (McLaren et al. 1984, Blokpoel and Tessier 1984).

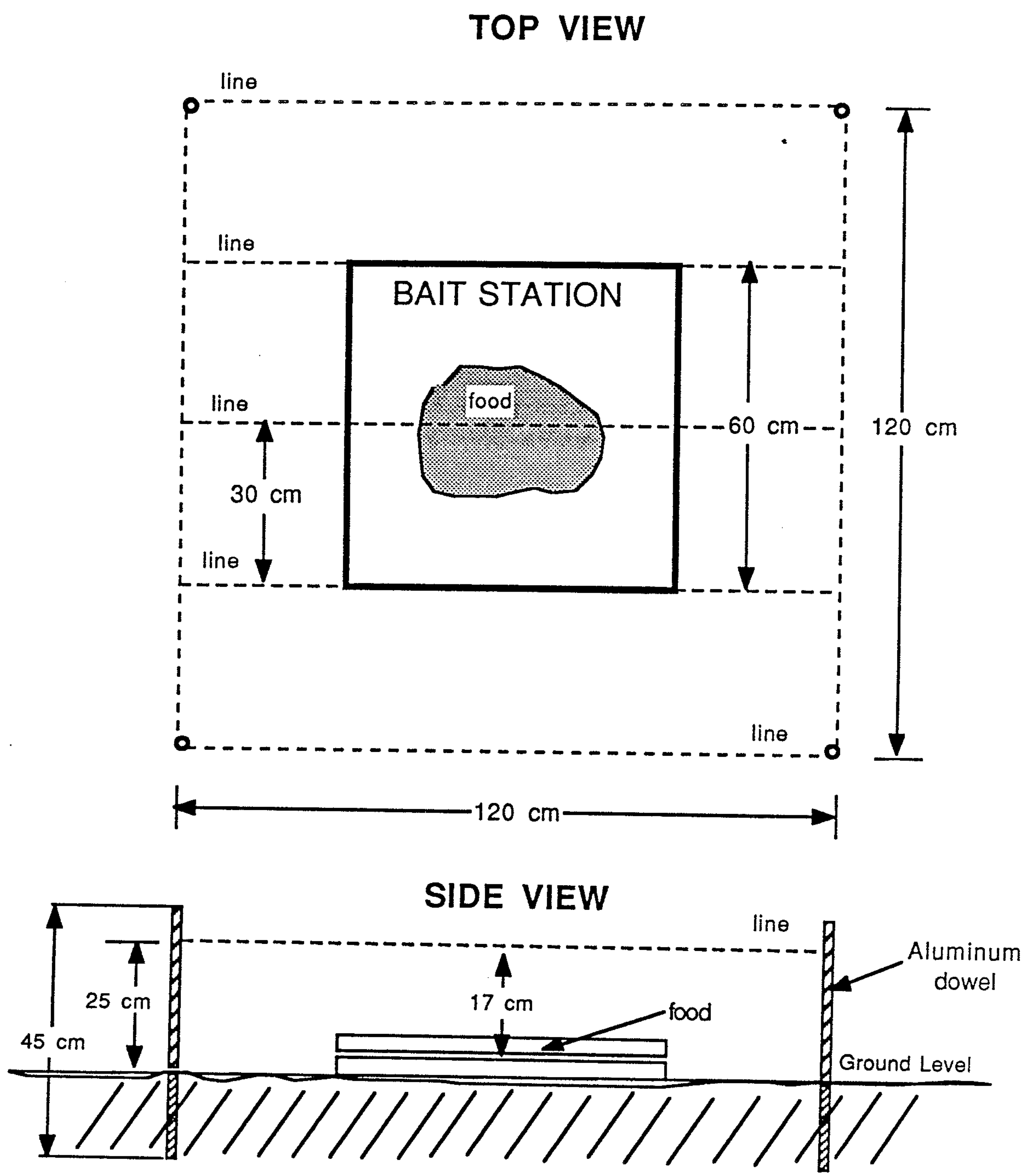


Fig. 2.1. Baited station showing lines installed at 30 cm spacings.

## RESULTS AND DISCUSSION

Data collected on the number of house sparrow-min at the control stations were compared with treatments and a highly significant difference was found in all experiments ($\underline{P} \leq 0.0003$; tables 2.1, 2. 2). Analogous to the bird-min counts, mean food consumption recorded at the control station was highly significant in comparison with treatments for experiments 1, 2 ($\underline{P} = 0.0002$) and, 3 ($\underline{P} \leq 0.0009$) (table 2.3). All experiments were successful in excluding house sparrows. Tests were conducted at different locations to evaluate the response of different house sparrow populations. The method was found to be highly effective in drastically reducing or eliminating the use of feeding sites by house sparrows.

In these experiments, few house sparrows visited the treatment stations (tables 2.1; 2.2). These birds remained for little time and essentially no feeding was observed. Other birds were seen feeding at stations. In experiments 1 and 2, European starlings (Sturnus vulgaris) were recorded at control and treatment stations ($\underline{P} \geq 0.86$). In experiment 3a, common grackles (Quiscalus quiscula) were counted at control (24) and treatments (15). Blue jays (Cyanocitta cristata) (6) were present at clear and golden stations with 60 cm spacing.

McAtee and Piper (1936) suggested that the correct distance between lines for repelling birds would depend on the species to be repelled, making size and wingspread of the bird important. For house sparrows, monofilament lines apparently are not a physical barrier because both 30 and 60 cm clearance is enough space to pass through in relation to the wingspan of the species that, according to Rue (1970), is 23.5 cm or 9.5 in.

The hypothesis in experiment 1 was based on the idea that line size and orientation could be an important factor in relation to visibility of lines. Lighter weight clear lines 1.8 kg- (4 pound-test) were expected to be less visible and therefore more difficult for house sparrows to enter. However, the only observations of house sparrows under the lines (5 bird-min) were under the lighter weight (1.8-kg test) line and in early morning low-light conditions. Possibly this 1.8 kg-test clear line was not visible enough under these conditions. In experiment 2, more visible lines were set on the treatments to test the hypothesis that lines work because they are visible but not visible enough to be easily avoided.

Results indicated that both clear (less visible) and golden fluorescent (more visible) monofilament lines worked equally well in excluding house sparrows. Therefore the hypothesis under these conditions was rejected because the golden was highly visible. Results obtained in experiment 3 indicated that house sparrow response to the lines did not show habituation, because the same response was observed in the house sparrow population previously exposed to the lines (old barn) and another not previously exposed (Agronomy farm).

In experiments 1 and 2, food at the control station was consumed early in the morning, often by 1-2 hours after sunrise but food on stations with lines remained untouched. Only 7 house sparrow-min were recorded at stations with lines. References indicate that in small birds, food intake increases when environmental temperature drops off (Kendeigh et. al 1977). Long cold winter nights are often critical for these species, and food may be limited for a house sparrow population in winter (Beer 1961). However, hypothermia may be an adaptation in house sparrows and chickadees when food is scarce, restricted, or not available in nature (Steen 1958). Although I am not sure that food was limited in these experiments, the lines did repel them from food that was essentially all consumed during pretreatment. These results indicate the effectiveness of the method in preventing house sparrow feeding. Despite the apparent need for food, house sparrows did not feed on stations with lines.

The number of house sparrows observed under the lines in experiment 3 was higher than in any of the others. Experiments 1 and 2 were conducted between December and March and experiment 3 was conducted in May and June. The higher number of house sparrows observed under the lines in experiment 3 (table 2.2) could possibly be related to the breeding season. At the old barn (experiment 3a), a low percentage of adult males were observed under the lines, but because it is difficult to discern between juveniles and females (Summers-Smith 1963), there is not enough support to indicate that both of these were present also. No adult males were observed under the lines at the Agronomy farm (experiment 3b). House sparrows observed under the lines at this site were identified as mostly young accompanied by females.

Of all observations on a particular station at the old barn site (experiment 3a), adult male house sparrow-min using the treatment stations were 6% on clear 60 cm, 16% on golden 60 cm, and 4% on golden 30 cm. No male birds were observed on the treatment using clear 30 cm. At the Agronomy farm (experiment 3b), no adults males were observed on stations with lines. House sparrows using the treatments at the Agronomy farm appeared to be juveniles and females helping to feed the juveniles. I captured 1 juvenile entangled in clear 60 cm line spacing and another 2 juveniles were observed hitting clear 60 cm. After young leave the nest they beg for food (Summers-Smith 1963). Adults continue to feed them for two weeks, and probably longer (Weaver 1942, Summers-Smith 1963). Food given to the young consists of only 32% grain or plant food, and the other 68% insects (Summers-Smith 1963). Cracked corn was the food used at stations; therefore, the observation of young and females under the lines could be related to food demand of young on the adults. Feeding the young may be an attraction that brings adult house sparrows to the treatment stations. I observed female house sparrows delivering food from inside and outside of the bait stations to young on treatment stations.

The higher number of house sparrows observed under the lines in experiment 3 may have biological significance in understanding why lines affect house sparrows. Although the mechanism to avoid the lines may differ among species, the idea of interference from lines in making a rapid escape in house sparrows is consistent with the observed more attentive response

Table 2.1. Number of house sparrow-minutes on bait stations protected by monofilament lines spaced 30 cm apart and stretched horizontally 17 cm above the food, Experiment 1, near old barn, Lincoln, Nebraska, Dec 1988-Jan 1989.

| Treatment | Line weight Kg (pound) | Orientation | No. house sparrow-min |
|---|---|---|---|
| Control | | | 833[a] |
| lines | 1.8 (4) | north-south | 1 |
| lines | 1.8 (4) | east-west | 4 |
| lines | 5.4 (12) | north-south | 0 |
| lines | 5.4 (12) | east-west | 0 |

[a]different from others in column at $\underline{P} = 0.0001$

Table 2.2. Number of house sparrow-minutes on bait stations protected by monofilament lines spaced 30 cm and 60 cm apart and stretched horizontally 17 cm above the food, Experiment 2 (near old barn), Experiment 3 [near old barn (a) and Agronomy farm (b)], Lincoln, Nebraska, 1989.

| Treatment | Line weight Kg (pound) | Line spacing (cm) | No. house sparrow-min Experiment No. | | |
|---|---|---|---|---|---|
| | | | 2 | 3a | 3b |
| Control | | | 934[a] | 958[b] | 386[c] |
| Clear | 5.4 (12) | 30 | 0 | 11 | 24 |
| Clear | 5.4 (12) | 60 | 1 | 30 | 29 |
| Golden | 9 (20) | 30 | 0 | 55 | 22 |
| Golden | 9 (20) | 60 | 1 | 80 | 17 |

[a]different from others in column at $\underline{P} = 0.0002$.

[b]different from others in column at $\underline{P} = 0.0001$.

[c]different from others in column at $\underline{P} = 0.0003$.

Table 2.3. Food consumption (g) on bait stations protected by monofilament lines stretched horizontally 17 cm above the food, experiment 1, 2, 3a (near old barn), and 3b, (Agronomy farm ), Lincoln, Nebraska, 1988-1989.

| Treatment | Line weight Kg (pound) | Line spacing (cm) | Orientation | Bait consumption(g) Experiment No. | | | |
|---|---|---|---|---|---|---|---|
| | | | | 1 | 2 | 3a | 3b |
| Control | | | | 575[a] | 374[a] | 713[b] | 192[b] |
| clear | 1.8 (4) | 30 | n-s | 153 | | | |
| clear | 1.8 (4) | 30 | e-w | 108 | | | |
| clear | 5.4 (12) | 30 | n-s | 102 | | | |
| clear | 5.4 (12) | 30 | e-w | 156 | | | |
| clear | 5.4 (12) | 30 | n-s | | 103 | 55 | 34 |
| clear | 5.4 (12) | 60 | n-s | | 118 | 122 | 62 |
| golden | 9 (20) | 30 | n-s | | 26 | 109 | 32 |
| golden | 9 (20) | 60 | n-s | | 117 | 89 | 37 |

[a] different from others in column at $\underline{P} = 0.0002$

[b] different from others in column at $\underline{P} \leq 0.0009$

than other species in regard to predators and other potential hazards (Arbid and Soper 1972; Dennis 1978). Therefore, lines may be avoided because they limit rapid escape from predators or other possible dangers. This response may change in presence of young. If this is true, this behavior should be observed during the breeding season only. Therefore, this type of response to the lines may be a seasonal effect because the two populations (exposed previously to lines and not exposed) reacted in the same way.

## SUMMARY

Monofilament lines to prevent feeding by house sparrows (Passer domesticus) at baited sites were tested at the University of Nebraska, Lincoln. Three experiments with controls were conducted using feeding stations to evaluate size [(1.8, 5.4 and 9 kg-test ( 4, 12, and 20 pound-test)] orientation (north-south, east-west), color (clear and golden fluorescent), and spacing (30 and 60 cm) of monofilament lines. The experimental design was a latin square 5 x 5 with periods and locations as blocking factors. Results of house sparrow counts and bait consumption data showed that lines effectively repelled house sparrows in all the experiments ($P \leq 0.0009$). Hypothesis in experiment 1 was based on the idea that line size and orientation could be an important factor in relation to visibility of lines. Both visibility and orientation were effective in repelling house sparrows. Experiment 2 evaluated 2 line spacings (30, 60 cm) and tested the suggestion that birds avoid lines because they can see them but not well enough to avoid them easily. The hypotheses in this experiment were that a wider spacing would be less effective than a narrow spacing, and that if the suggestion was correct, then highly visible lines would be less effective than moderately visible ones. Both clear (less visible) and golden fluorescent (more visible) monofilament lines worked equally well in excluding house sparrows. Experiment 3 examined whether any difference examined whether any difference would be noted in the response of a house sparrow population experienced with lines compared to one never before exposed. No difference was observed indicating that no habituation had developed in the previously exposed population. Therefore lines appear to offer a simple, safe, and effective means to reduce problems caused by house sparrows at feeding sites, a finding not been previously experimentally determined.

# CHAPTER 3

# MONOFILAMENT LINES AND MULTIPLE SPECIES

## MONOFILAMENT LINES AND MULTIPLE SPECIES

Monofilament fishing lines have been used at nesting sites of ring-billed gulls (Blokpoel and Tessier 1983), at hatcheries to avoid herring gull predation on fish (Ostergaard 1981) and at public open-air places (Blokpoel and Tessier 1984). Recently, preliminary trials with monofilament lines spaced 30 cm apart showed success in protecting grapes and strawberries from terrestrial birds, especially house sparrows (J. M. Knight, pers. comm.). Knight (1988) also reported some procedures using lines to protect row crops, fruit trees, vineyards, bedded crops from bird damage. Monofilament lines used in a grid pattern in citrus crops reduced damage by great-tailed grackle (Quiscalus mexicanus) (Tipton et al. 1989).

Monofilament lines in various weights [(1.8, 5.4, and 9 Kg-test (4, 12, and 20 pound-test)], colors (clear and golden fluorescent) and spacings (30 cm and 60 cm) were equally effective in repelling house sparrows at baited sites (chapter 2). The reasons why lines repel certain birds is not fully understood and there are no apparent patterns among species that explain why lines repel certain birds but not others (Pochop et al. 1990). McAtee and Piper (1936) suggested that effective distance between lines would vary with the size of the species to be repelled, making size and wingspread of the bird important. European starlings (Sturnus vulgaris) and American robins (Turdus migratorious) are large enough that 30 cm spacing of monofilament lines appears to be too close for them to pass through easily. However, they pass through this 30 cm spacing easily, and monofilament lines were ineffective in repelling these species (chapter 1). House sparrows, which are smaller than the starlings and robins, were effectively repelled by 30 cm and 60 cm spacings (chapter 2). Indeed, traits other than bird size and wingspread in relation to these species must be considered.

The objective of this experiment was to evaluate the response to monofilament lines of other species that often occur at feeding stations along with house sparrows. Understanding how other species respond may show patterns that better clarify why lines repel some species and not others. The hypothesis tested in this experiment were that a wider spacing (60 cm) would be less effective than a narrow spacing (30 cm).

## STUDY SITE AND METHODS

The study was conducted on 7-18 March 1989 at the University of Nebraska, East Campus Horticultural garden. The site was prebaited for 2 days by scattering a mixture of white proso millet and sunflower seeds on the ground. Three bait stations like those used in earlier experiments (fig 2.1) were established, one was control without lines and two were treatments with clear 5.4 kg-test (12 pound-test) monofilament lines spaced 30 cm or 60 cm apart. A 12-day experiment was run in which days 1-3 were a prebait period without lines on stations. A mixture of 90 g sunflower and 30 g white proso millet seeds were placed daily on each station at dawn and collected immediately after dusk. Daily bait consumption was recorded. Four 15-min observation intervals were randomly chosen from each of three portions of the day: within 3 h after sunrise, 3 h midday, and 3 within h before sunset. During observation periods, instantaneous counts of the birds at each bait station were recorded each minute. Birds were observed with binoculars (7 x 50) from the second floor of a storage barn. The line of stations was located perpendicularly to this barn and 18-24 m south. Distance between stations was approximately 3 m. The experimental design was a 3 x 3 latin square. Periods and locations were randomly rotated to block their effect on treatments. Results of bird counts (bird-min) and bait consumption were analyzed using analysis of variance and orthogonal contrasts. Comparisons made using contrasts were: treatment versus control and 30 cm versus 60 cm spacings.

## RESULTS AND DISCUSSION

Results indicate that 4 species of passerine birds were not repelled by monofilament lines but 3 other species may be affected. These results denoted no differences in the number of bird-min on treatment versus control stations, and on 30 cm versus 60 cm spacings for black-capped chickadees (Parus atricapillus) ($P$ = 0.47), dark-eyed juncos (Junco hyemalis), ($P$ = 0.16), Harris sparrows (Zonotrichia querula) ($P$ = 0.85), and mourning doves (Zenaida macrura) ($P$ = 0.69) (Table 3.1). The latter species often had been seen walking under the lines to the feeding stations. Chickadees always flew through the lines to food, and Harris sparrows and dark-eyed juncos flew and hopped to the food. All of these 4 species are associated with woodlands and forests (Johnsgard 1977, Ehrlich et al. 1988, p 552), but they showed different foraging patterns in coming to the feeding stations. For example morning doves walked under lines to get the food, possibly because of their larger size and wingspan. Harris sparrows, juncos, and chickadees seemed unaffected by the lines. Although the number of chickadees in this experiment was low, observed their behavior flying to all stations without hesitation adds support to the stadistical result of no effect from lines. Chickadee means (bird-min) at control, at 60 and at 30 cm treatments indicate that they were constantly present in all the stations and data may be more reliable (table 3.1). Bait consumption did not show difference among treatments ($P$ = 0.68) but was not expected to do so because of the variety of species using the food stations. References from the literature indicate that some spacings and heights of lines use are or have seen were more effective in repelling some species of birds than others (Pochop et al. 1990). Birds larger and smaller than house sparrows (chapter 1, this chapter) were able to fly through or walk under lines that repel house sparrows (Passer domesticus). Therefore the size and wingspan of a bird does not fully explain the likelihood of response to lines.

Although a comparison of house sparrow counts between control and treatments was not significant, house sparrows clearly maintained the same pattern as in experiments 1 and 2 (chapter 2). However the small number of house sparrows in this experiment and the confounding factor that house sparrows sometimes arrived in small groups, likely contributed to this statistical result. Results from chapter 2 experiments and the pattern in this experiment show that house sparrow numbers were effectively repelled by the spacing and size of the lines tested at the feeding stations. Thus, although house sparrows numbers in this experiment were low, their avoidance of lines appears to match earlier results.

Northern cardinals (Cardinalis cardinalis) and blue jays (Cyanocitta cristata) seemed to be affected by the lines at both 60 and 30 cm spacings. If these two species are repelled by the lines, this response may be related to their size and wingspan however, their numbers were not enough to allow some any reliable conclusion about their response. But further observations will be necessary to resolve this issue.

Table 3.1. Mean number of bird-minutes on food stations protected by clear 5.4 kg-test (12 pound-test) monofilament lines stretched horizontally 17 cm above the food, Horticultural garden, Lincoln, Nebraska, March 1989.

| Bird species | Mean bird-min on treatments | | | |
|---|---|---|---|---|
| | Total bird-min | Control $\bar{x}$ (SE) | 60 cm $\bar{x}$ (SE) | 30 cm $\bar{x}$ (SE) |
| Dark-eyed junco | 2158 | 16.1 (0.03) | 15.0 (0.03) | 14.6 (0.03) |
| Harris sparrow | 1310 | 12.1 (0.06) | 11.2 (0.07) | 12.6 (0.06) |
| Mourning dove | 433 | 6.5 (0.08) | 7.2 (0.07) | 6.4 (0.08) |
| Northern cardinal | 83 | 4.6 (0.10)[a] | 2.2 (0.21) | 0.3 (0.88) |
| Black-caped chickadee | 56 | 2.7 (0.24) | 1.4 (0.39) | 2.4 (0.28) |
| House sparrow | 56 | 3.2 (0.24) | 0.8 (0.69) | 0.3 (1.68) |
| Blue jay | 38 | 3.1 (0.15)[b] | 0.3 (0.92) | 0.0 (0.00) |

[a]different from treatments at P = 0.04

[b]different from treatments at P = 0.03

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APPENDIX

## MONOFILAMENT LINE DISTANCES

Spacings of 30 cm and 60 cm of monofilament lines were highly effective in repelling house sparrows (Chapter 2). Wider spacings were attempted to evaluate the response of house sparrows to line at feeding sites.

### Materials and Methods

This trial using monofilament lines was designed to evaluate the feeding response of house sparrows to wider spacings of lines. The test was conducted during 21 days from 18 April through 9 May 1989. Site, type of aluminum dowels, and data collected were the same as experiment 1 (Chapter 2). Two feeding boards 244 x 30 cm (1 x 8 ft) were constructed. Each board consisted of 8 30 x 30 cm compartments of 930 sq cm (1 sq ft). Each compartment had a 4 cm high outside edge to avoid grain loss. Based on bait consumption in earlier experiments, an amount of 12 g of cracked corn was used in each compartment. Clear 5.4 kg-test (12-pound) monofilament lines were stretched across the board according to the chosen spacing to test, and were held in place by aluminum dowels 100 cm apart. Thus, lines were 100 cm long and horizontal, and they crossed the board 13 cm directly above a compartment divider (fig 2.2), but at a height of 17 cm above the food. There was a distance of 15 m between boards.

After a prebaiting period of 3 days (no lines), 6 different spacings using monofilament lines were tested at each board position (table A.1). Two line spacings were used on the 2 boards, 1 spacing each, for 3 days, after which the treatments were switched between the boards. Thus each treatment was observed for 6 days, 3 on each board. Spacings tested together were 183 cm (6 ft) and 122 cm (4 ft); 90 cm (3 ft) and 60 cm (2 ft); and 90 cm (3 ft) and 60 cm (2 ft), each with an additional line on the outside border (fig 2.3-2.8). Bird observations were made during 4 15-minute intervals randomly selected during the first 3 h after sunrise, after which any remaining bait was removed and consumption was recorded. During observation periods, instantaneous counts of the birds at each compartment were recorded each minute, starting with 0 (16 observations per interval). Bird count (bird-min) and bait consumption (in each compartment) were averaged over 6 days for each treatment. These were preliminary observations without controls, and therefore no statistical analysis was obtained.

Results and discussion

House sparrows were the birds most abundant at the boards. A total of 596 house sparrow-min were counted including the pretreatment (287). Numbers of other species such as common grackles (Quiscalus quiscula) (70), European starlings (38), white crowned sparrows (Zonotrichia leucophrys) (12), and blue jays (1) were recorded at the compartments during the trial. The mean number of house sparrow-min observed indicated that wider spacing (183 and 122 cm) of lines also reduced house sparrows number drastically when compared with the pretreatment (fig 2.3). House sparrows generally at least 30 cm stayed away from the line. The mean number of house sparrows increased as distance between lines expanded (fig 2.3-2.5). But always, these numbers were lower than those of the pretreatment.

This preliminary test contributes to the understanding of how spacing between lines may affect house sparrow feeding. Apparently more space between lines is less effective. Although the mechanism to avoid the lines may differ among species and the reasons why lines repel certain birds is not fully understood, there are no apparent patterns among species that explain the efficacy of lines in repelling various birds (Pochop et al. 1990). However the idea of interference from

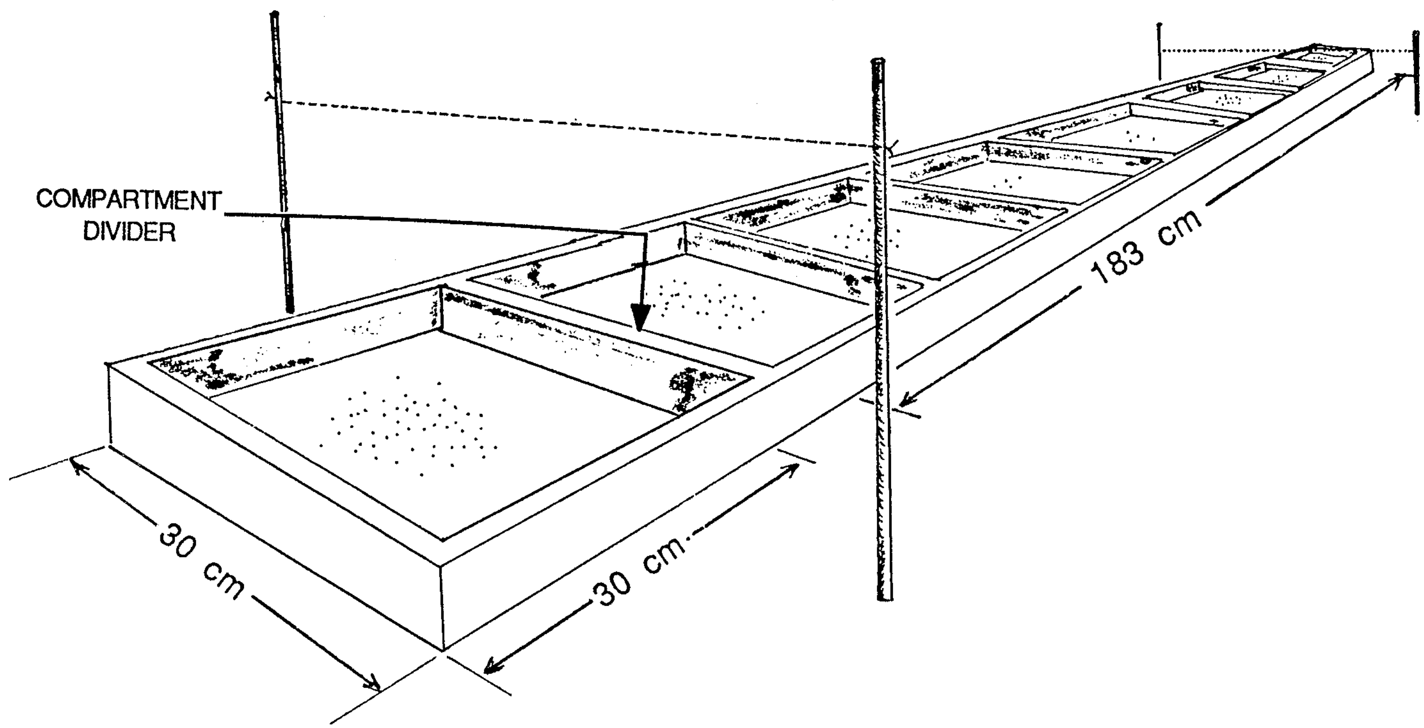


Fig. 2.2 Board and lines

lines in making a rapid escape in house sparrows may be a reason why house sparrows keep away from the lines.

Although other species were feeding in the compartments, house sparrows were the most abundant bird feeding at the boards. The mean amount of bait consumed showed the same tendency as the mean bird counts (fig 2.6-2.8) and the 30 and 60 cm spacing again appeared to be more effective in repelling house sparrows than other wider spacings.

An increase in numbers of house sparrows under the lines in comparison with earlier experiments was observed. Some of them came to the board by hopping. The increased numbers of house sparrows under the lines compared to earlier experiments (Chapter 2) might be explained by habituation or by seasonal effect. Because this trial was done at the same site as experiments 1 and 2 (Chapter 2), it was stimulated the design of the experiment 3 in order to test whether habituation or seasonal effect was the more likely reason for the observed shift in behavior toward lines.

Table A.1. Experimental procedures with 2 bait boards, Lincoln, Nebraska, April-May 1989.

| Days | Line spacing (cm) | |
|---|---|---|
| | Board 1 | Board 2 |
| 1-3 (pretreatment) | -- | -- |
| 4-6 | 183 | 122 |
| 7-9 | 122 | 183 |
| 10-12 | 60 | 90 |
| 13-15 | 90 | 60 |
| 16-18 | 60 with border lines | 90 with border lines |
| 19-21 | 90 with border lines | 60 with border lines |

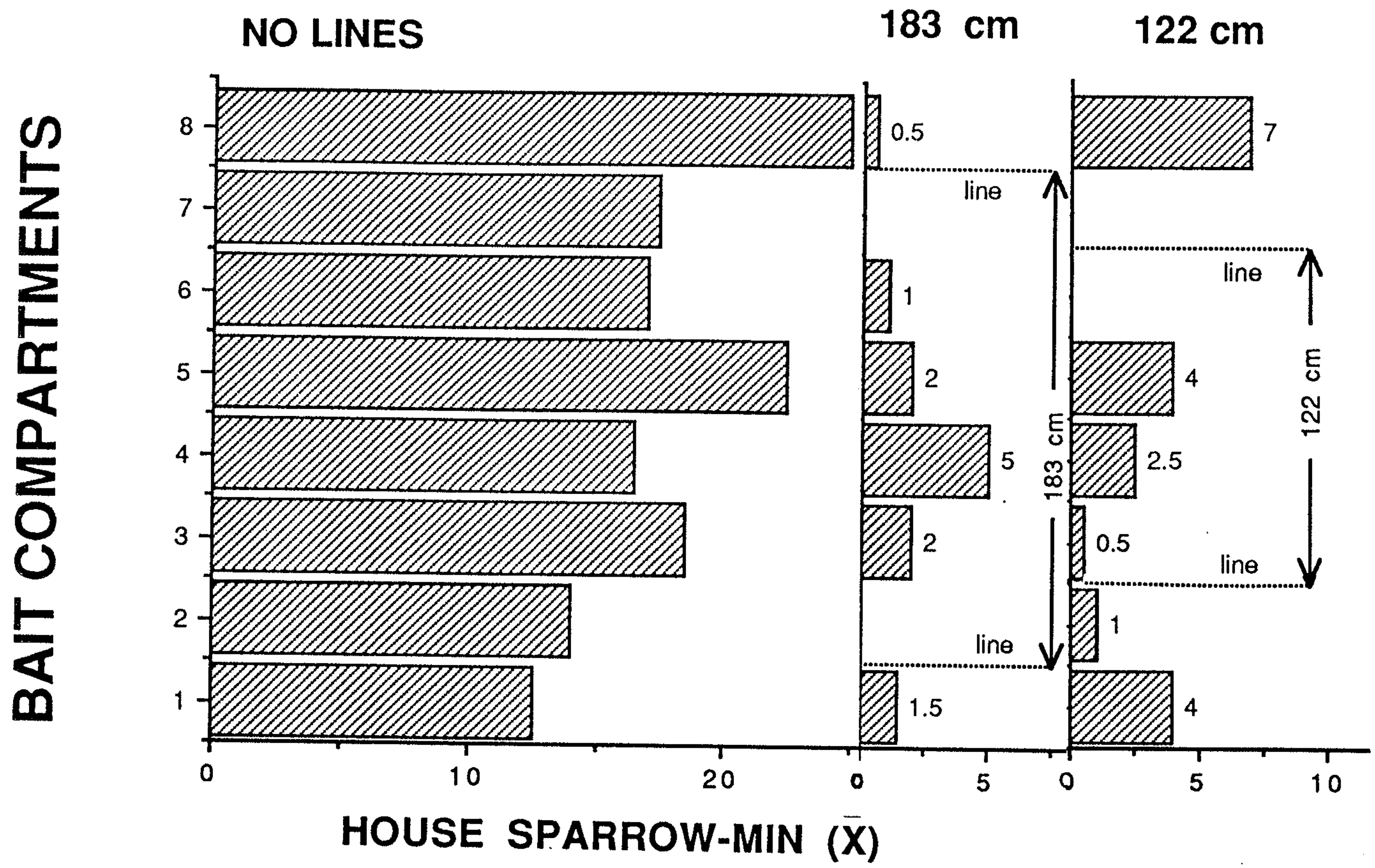


FIG. 2.3. MEAN NUMBER OF HOUSE SPARROW-MIN OBSERVED IN ADJACENT 30 X 30 CM FOOD COMPARTMENTS THAT HAD NO LINES OR WERE PROTECTED BY MONOFILAMENT LINES STRETCHED ACROSS THE COMPARTMENTS 17 CM ABOVE THE FOOD AND SPACED 183 OR 122 CM APART, LINCOLN, NEBRASKA, APRIL-MAY 1989.

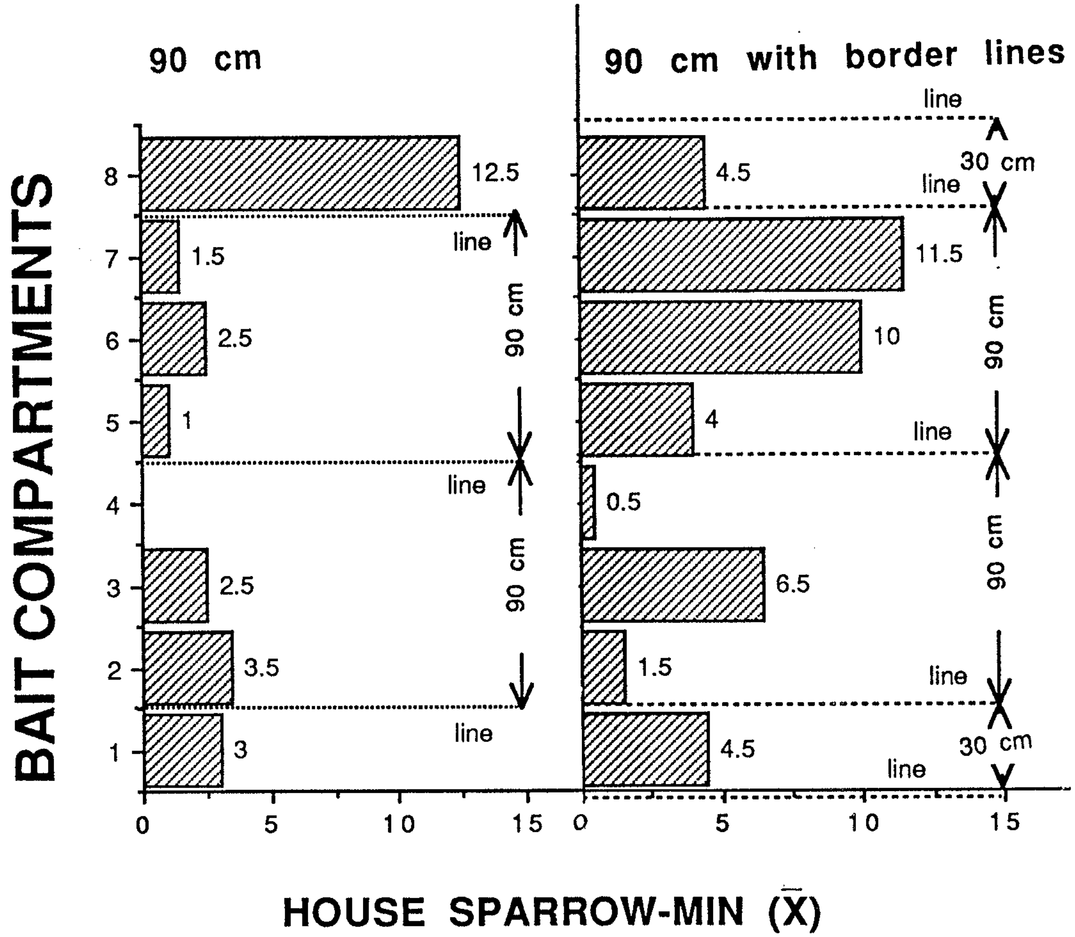


FIG. 2.4. MEAN NUMBER OF HOUSE SPARROW-MIN OBSERVED IN ADJACENT 30 X 30 CM FOOD COMPARTMENTS THAT HAD LINES STRETCHED ACROSS THE COMPARTMENTS 17 CM ABOVE THE FOOD AND SPACED 90 CM, LINCOLN, NEBRASKA, APRIL-MAY 1989

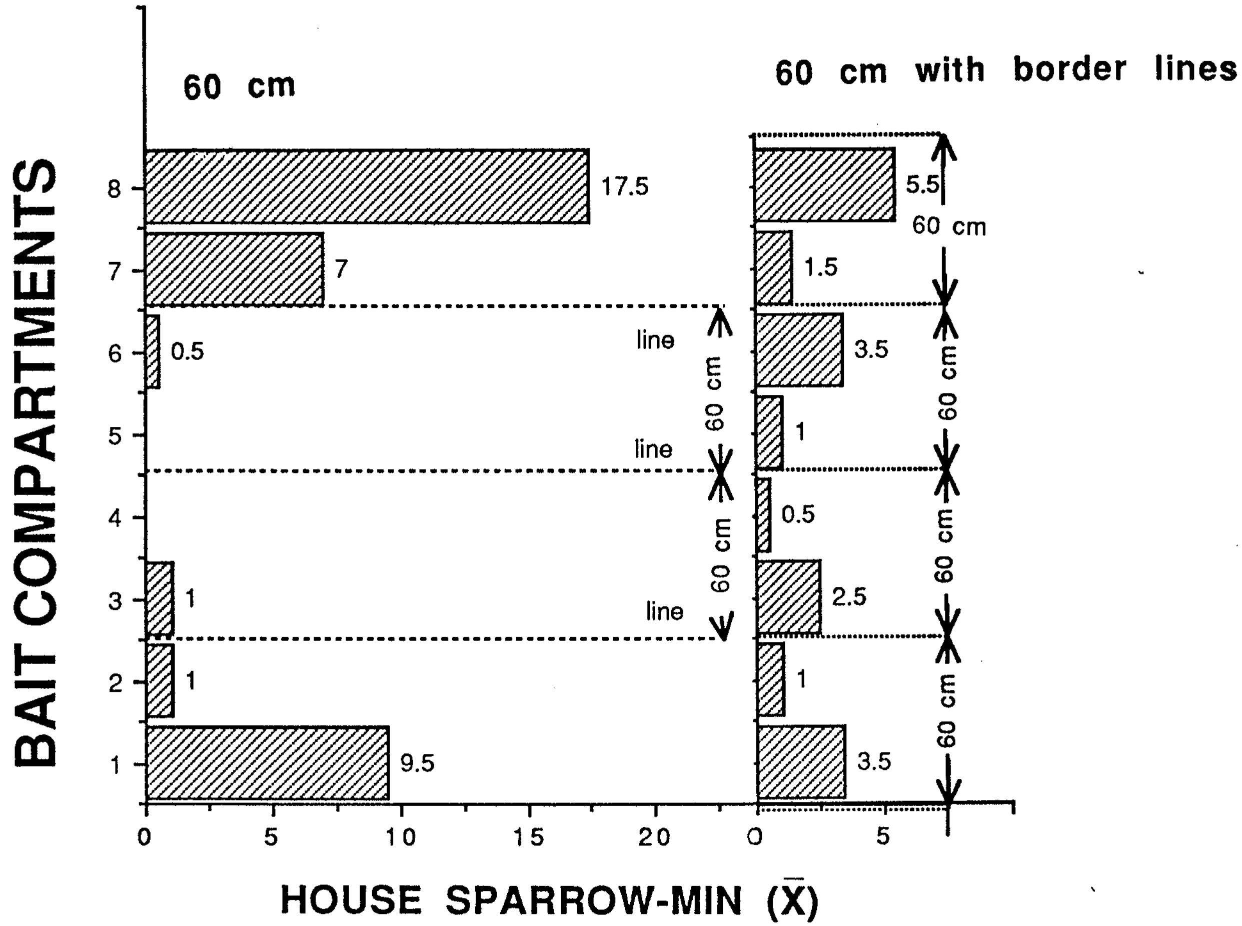


FIG. 2.5. MEAN NUMBER OF HOUSE SPARROW-MIN OBSERVED IN ADJACENT 30 X 30 CM FOOD COMPARTMENTS THAT HAD LINES STRETCHED ACROSS THE COMPARTMENTS 17 CM ABOVE THE FOOD AND SPACED 60 CM, LINCOLN, NEBRASKA, APRIL-MAY 1989

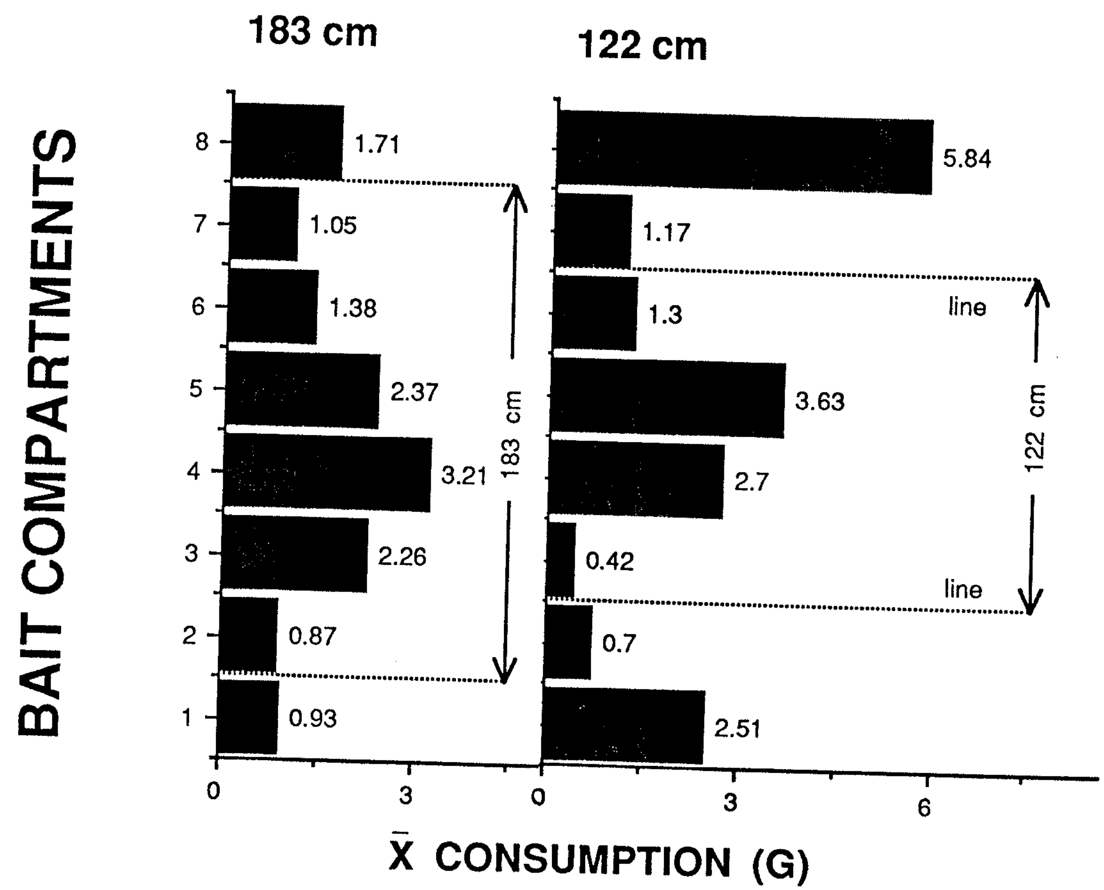


FIG. 2.6. MEAN OF FOOD CONSUMPTION (G) IN ADJACENT 30 X 30 CM FOOD COMPARTMENTS THAT HAD LINES STRETCHED ACROSS THE COMPARTMENTS 17 CM ABOVE THE FOOD AND SPACED 183 OR 122 CM APART, LINCOLN, NEBRASKA, APRIL-MAY 1989.

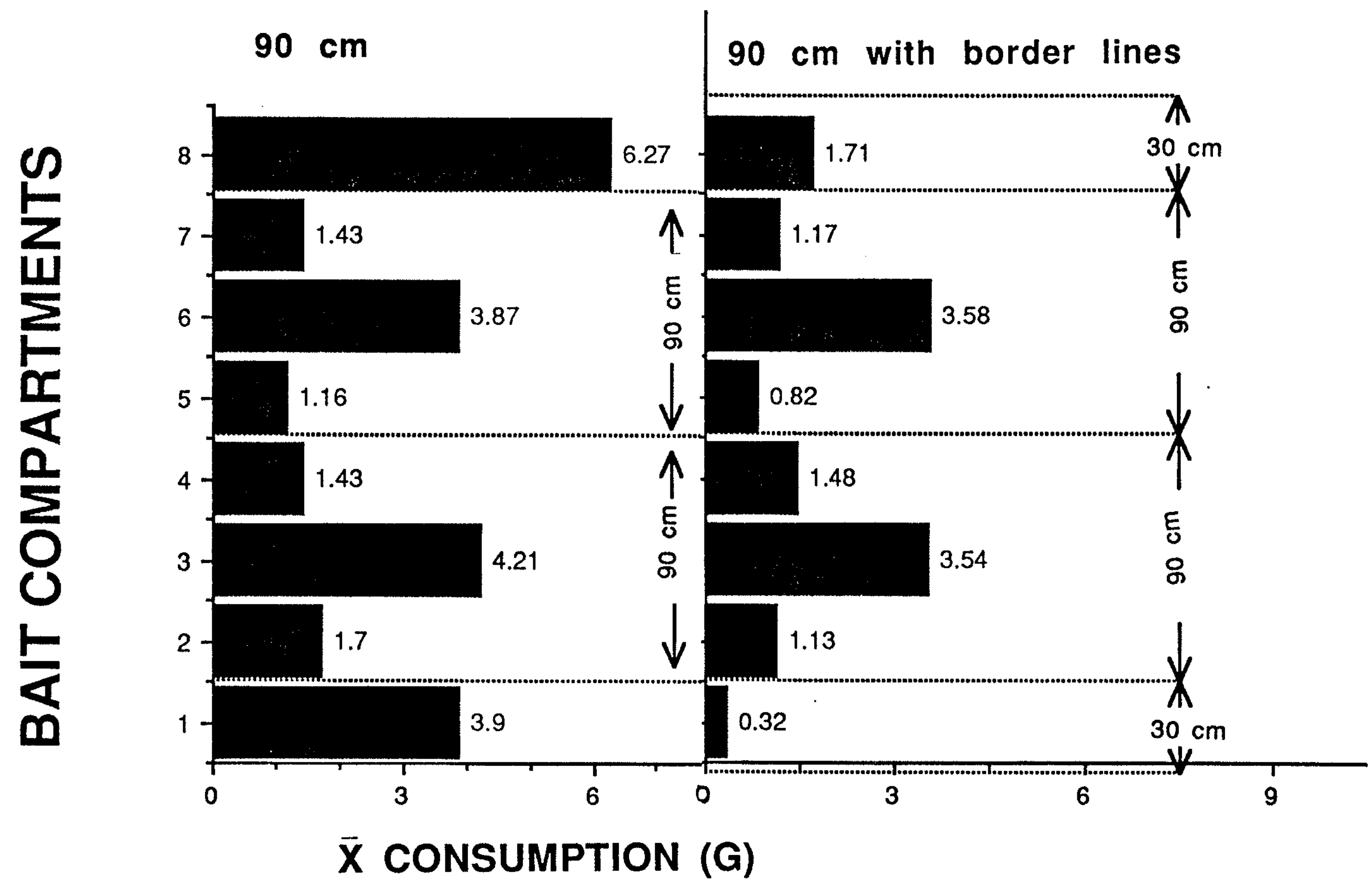


FIG. 2.7. MEAN OF FOOD CONSUMPTION (G) IN ADJACENT 30 X 30 CM FOOD COMPARTMENTS THAT HAD LINES STRETCHED ACROSS THE COMPARTMENTS 17 CM ABOVE THE FOOD AND SPACED 90 CM APART LINCOLN, NEBRASKA, APRIL-MAY 1989.

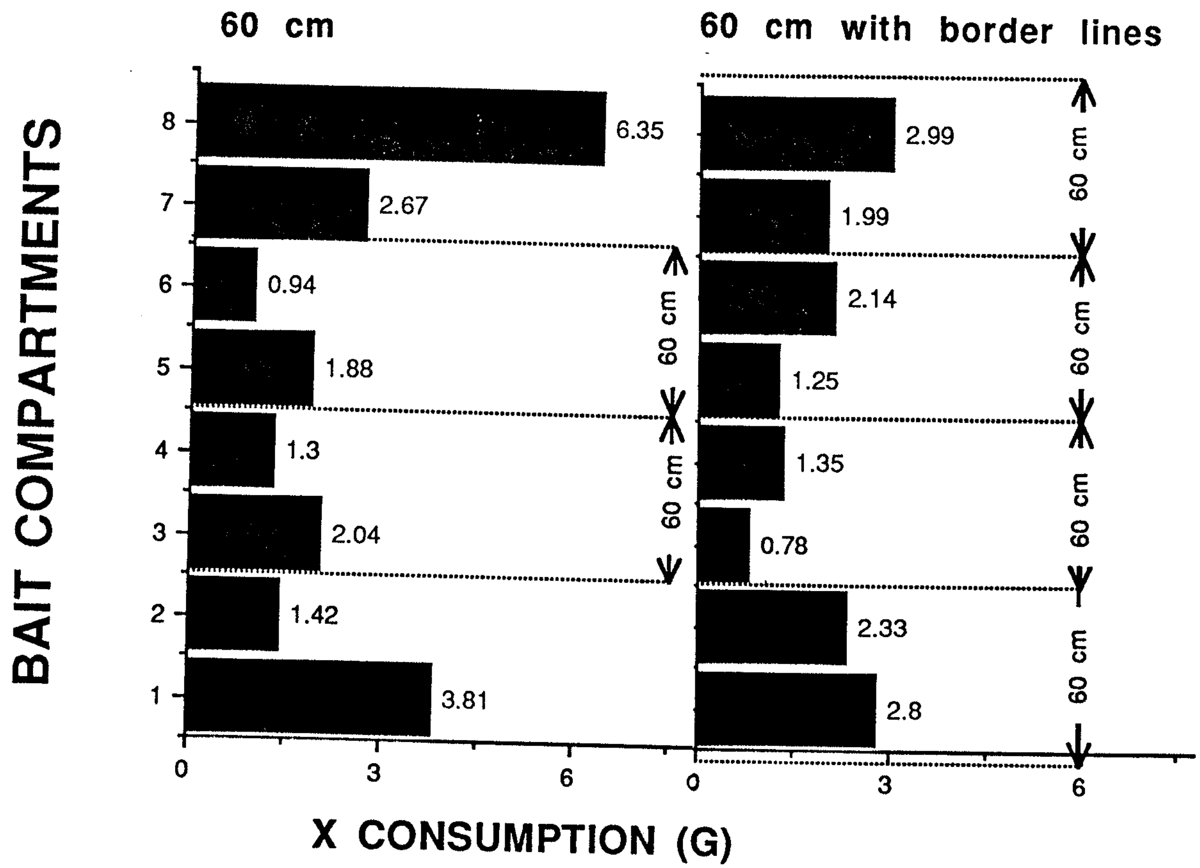


FIG. 2.8. MEAN OF FOOD CONSUMPTION (G) IN ADJACENT 30 X 30 CM FOOD COMPARTMENTS THAT HAD LINES STRETCHED ACROSS THE COMPARTMENTS 17 CM ABOVE THE FOOD AND SPACED 60 CM APART LINCOLN, NEBRASKA, APRIL-MAY 1989.